

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: August 28, 1979

Project Title: Intergovernmental Personnel Assignment - Michiko Nakagaki

Project No: E-20-670

Project Director: Dr. S. N. Atluri

Sponsor: Naval Research Laboratory; Material Science & Technology Division

Agreement Period: From 9/1/79 Until 8/31/81

Type Agreement: IPA Agreement No. N00173-79-IPA-09

Amount: \$29,390

Reports Required: n/a

Sponsor Contact Person (s):

Technical Matters

Dr. C. I. Chang, Head
Numerical Simulation Consultant Staff
Material Science and Technology Division
Naval Research Laboratory
Washington, D. C. 20375

Contractual Matters

(thru OCA)

Dr. Alan Berman
Director of Research
Naval Research Laboratory
Washington, D. C. 20375

Defense Priority Rating: n/a

Assigned to: Civil Engineering (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director-EES
Accounting Office
Procurement Office
Security Coordinator (OCA)
✓ Reports Coordinator (OCA)

Library, Technical Reports Section
EES Information Office
EES Reports & Procedures
Project File (OCA)
Project Code (GTRI)
Other _____

SPONSORED PROJECT TERMINATION SHEET

Date 10/12/81

Project Title: Intergovernmental Personnel Assignment

Project No: E-20-670

Project Director: Dr. S. N. Atluri

Sponsor: Naval Research Laboratory
Material Science & Tech. Div.

Effective Termination Date: 8/31/81

Clearance of Accounting Charges: 8/31/81

Grant/Contract Closeout Actions Remaining:

- ☒ Final Invoice ~~and Closing Documents~~
- ☐ Final Fiscal Report
- ☐ Final Report of Inventions
- ☐ Govt. Property Inventory & Related Certificate
- ☐ Classified Material Certificate
- ☐ Other _____

Continued by E-20-634

Assigned to: Civil Engineering (School/Laboratory)

COPIES TO:

Administrative Coordinator
Research Property Management
Accounting
Procurement/EES Supply Services

Research Security Services
~~Reports Coordinator (OCA)~~
Legal Services (OCA)
Library

EES Public Relations (2)
Computer Input
Project File
Other _____

GEORGIA TECH FUSION STUDIES PROGRAM

Contract DE-AS05-78ET-52025
Quarterly Progress Report
for January 1 - March 31, 1981

Ripple Reduction Poloidal Field Coils for Tokamaks

Ripple reduction poloidal field (RRPF) coils consist of dipole coils placed above and below the tokamak plasma to produce the vertical field needed for plasma equilibrium and at the same time designed to reduce magnetic ripple from the discrete toroidal field (TF) coils.

An example of an RRPF coil set designed for an INTOR or ETF tokamak reactor is completely described in the attached draft of report GTFR-26. In this particular example, the magnetic ripple from eight TF coils is reduced from more than 2% at the outer edge of the plasma to less than 0.2% over much of the plasma cross section. A patent application is being pursued.

The advantages of ripple reduction poloidal field coils are:

- 1) Some or all of the poloidal field coils can be placed close to the plasma (just outside the blanket and shielding) without linking the TF coils. Hence less current is needed in RRPF coils than in conventional poloidal field (PF) coil designs placed outside the TF coils. For example, the RRPF coils described in the draft of GTFR-26 require less than five M Amp turns while some of the INTOR PF coils require more than 26 M Amp turns. With less current required, less coil material is needed and they are less expensive. RRPF coils are also made of modular coils which are considerably smaller than conventional PF coils. It should be kept in mind that construction of the Joint European Tokamak is being delayed because it was difficult for European industry to make the very large PF coils used in that design.
- 2) With the use of ripple reduction poloidal field coils, tokamaks can be designed with fewer TF coils for greater access to the plasma chamber. For example, the design presented in the draft of GTFR-26 uses only eight TF coils while reducing the magnetic ripple to acceptable limits. Alternatively, the TF coils can be made somewhat smaller or the plasma chamber can be made somewhat larger for a given set of TF coils. Costs are reduced and construction is simplified.
- 3) Magnetic ripple can easily be varied over a wide range for fusion burn control when RRPF coils are used.

Work is in progress to further optimize the design of ripple reduction poloidal field coils for tokamak reactors. The design will be altered to produce the desired vertical and shaping fields needed for plasma equilibrium. An attempt will be made to reduce ripple even further. It is hoped that this idea can be implemented in the next large tokamak to be built by the U. S. Department of Energy.

Impurity Flow Reversal

The theory for impurity flow reversal in tokamaks, caused by co-injection of a momentum source, was extended to a set of equations for a plasma with three disparate mass species in a mixed collisionality regime. This collisionality situation is typical in present day tokamak experiments and is expected to exist in future devices, at least in the edge region. The results are consistent with the previous two species findings reported in GTFR-21 (Dec., 1980). The momentum input to the two lighter species is seen to drive the heaviest species outward, the lightest species inward, and the middle species more slowly inward or outward depending on the relative concentrations and masses of the three species. Extensions of a momentum drag model to fit this situation are being performed and a computer analysis is planned.

Attachment: DRAFT GTFR-26

GEORGIA TECH FUSION STUDIES PROGRAM

Quarterly Progress Report, January 15, 1981

Bundle Divertor Studies

A wide variety of bundle divertor designs for a tokamak fusion reactor similar to INTOR were studied in report GTFR-20, which will appear in the Proceedings of the American Nuclear Society 4th Topical Meeting on the Technology of Controlled Nuclear Fusion (King of Prussia, PA, 14-17 October 1980). All the designs provided adequate clearance for neutron shielding and satisfied engineering constraints on the maximum allowable coil stress, cooling requirements, radiation damage and so forth. The best bundle divertor design had a clear throat aperture 0.6 m high by 1.0 m wide and produced a localized magnetic ripple of about 1.2% at the geometric center of the plasma. Smaller bundle divertors with less shielding would produce less magnetic ripple in the plasma, but would be less effective at diverting the edge of the plasma and would not last as long in a tokamak reactor.

A study of hybrid bundle divertors was initiated during November 1980 in an effort to reduce the magnetic ripple while increasing the amount of diverted plasma. Our first hybrid bundle divertor design, which is described in report GTFR-23, reduced the ripple at the center of the plasma to 0.3% while increasing the throat aperture to 1.0 m high by 1.8 m wide. Clearance of about 0.7 m is provided for neutron shielding and coil dimensions. Each of the three parts of the divertor can be pulled out between toroidal field coils for access or replacement. The hybrid divertor has the added advantage of spreading out the scrape off layer (from 0.1 m to 0.7 m) which reduces the local heat flux to the collector plate. Further optimization work is in progress.

Impurity Flow Reversal

A computer analysis of impurity flow reversal in tokamaks caused by co-injection of a neutral beam momentum source was performed using fixed density and temperature profiles. It was found that the impurity flow observed in the PLT and ISX tokamak experiments during neutral beam injection could be explained using this momentum drag model. Analysis indicated that this mechanism would be useful for controlling impurities in an FED sized tokamak reactor. The dependence of the results on beam angle and power was investigated. Part of this work was performed in collaboration with D. J. Sigmar and E. C. Crume at Oak Ridge National Laboratory for the FED project. A detailed description of the basic model appears in report GTFR-21 (December 1980).

Effect of Magnetic Ripple

The development of a computer program package for the calculation of ripple-induced plasma diffusion in realistic tokamak geometry was finished. The package allows for the calculation of the plasma diffusion and thermal conductivity given any tokamak plasma cross section and any magnetic ripple configuration. An optional package for predicting the effect of a poloidal divertor was also developed.

Calculations were made on the effect of ripple induced transport in the ISX tokamak experiment at Oak Ridge National Laboratory. A paper on this subject was presented at the American Nuclear Society Washington meeting. The results indicated that significant ripple transport effects could be induced in the experiment and, in fact, were observed. Ripple induced transport remains as the most important known mechanism capable of controlling the plasma during the burn phase of an ignited tokamak reactor.